

X.—Museum Notes.

I. ZOOLOGICAL.

ON THE FUNGUS PARASITES OF INSECTS.

The following notes have been communicated by Professor Roland Thaxter of Harvard University, who has made a considerable study of this interesting subject for many years past. During the last two years small collections of likely insects have been made by Malays under directions received from Professor Thaxter and sent to him for study. He reports that a variety of fungus forms have been obtained from these insects and that many of them are entirely new to science. Bearing in mind the enormous extent of insect life in Borneo and the fact that it has not been collected here or examined so far for this particular study, except in a very few instances—an infinitesimal portion of what might be done—I would like to call the attention of any Sarawak readers interested in botany or entomology, to this untouched field of work, which, as Professor Thaxter points out, has a great economic value. We know that plants are affected by insects and that whole crops are often completely destroyed by their agency, but it may not have occurred to some that these insects are liable to disease, which, in the form of fungus-parasites, can completely destroy any insects thus infected. Now, it is possible to infect these noxious insects (harmful to crops), with some of these diseases, kill off the insects and thus save the crops. The immense value to agricultural science of an extensive knowledge of this subject is obvious; but the study at present is practically in its infancy and more material is urgently required to assist this study. If any reader would communicate with me or with Professor Thaxter, instructions and apparatus for collecting would be gladly supplied, and the collector would have the satisfaction of knowing that in all probability he would be making an important contribution to science.

There are few more curious natural productions than are to be found among the fungus parasites of insects which, although they are seldom recognized even

by those specially interested in natural history, are nevertheless widely distributed, especially in the tropics, and are far more varied and abundant than is generally supposed.

Of the many provisions which nature has developed for the destruction of its surplus insect population, there are few more effective in restraining the undue increase of many forms than these fungus diseases which, in some instances, may afford the most effective means of destroying noxious species. Among these fungus parasites there are several different classes which do their work in different ways, some of them as destructive as the plagues which ravage higher animals and often more acutely epidemic; while others, even more peculiar from a scientific standpoint, depend for their existence on the continued life of their host-insects, exerting no destructive influence.

Among destructive forms the Entomophthorae or "Fly fungi," which take their vulgar name from a disease of the house fly, common all over the world, are responsible for widespread epidemics among various insects: flies, grasshoppers, caterpillars, plant-lice and many others, the contagion being scattered in this instance by means of "spores" which are shot off from their filaments by a special mechanism with great force and in countless numbers; a single spore bearing certain death to any proper host which it may touch. If therefore a disease of this nature is once started in a region where its proper victims are present in great numbers it may, if the weather conditions are favorable for its development, bring about an almost total destruction of its hosts over wide areas. The economic importance of such diseases has been more fully recognized in recent years and one of the Entomophthora diseases has been used artificially and with success in the United States for the last three seasons in an attempt to control the widespread destruction wrought by the caterpillars of the Brown-tail Moth, which, since its importation on nursery stock from Europe a few years ago, has increased to such an extent that it has devastated the forests in many parts of New England.

Fungus diseases of this group, however, do not appear to have been largely developed in the tropics

or have at least been generally overlooked. A few forms are recorded from Java and the West Indies, but they either do not occur abundantly or have not been recognised by observers. But in the tropics other diseases of this nature find conditions most congenial for their development, and although they usually work unseen and might not be recognized except by experts, are certainly responsible for widespread mortality among insects, noxious and otherwise, of various orders. Such forms belong for the most part to the great fungus group of "Ascomycetes," the more striking forms belonging to the genus *Cordyceps*, which produce the so called "vegetable worms," etc., and its imperfect or isarial conditions. Such fungi attack the larvae or the perfect insects or their chrysalids, and convert them into mummies by the growth of fungus filaments within the body. The insect thus dies wherever it may be; buried in the ground, in rotten wood, or on the surface of the ground. In many cases where perfect insects are attacked they become fastened to the under sides of leaves, or to twigs, or other objects, by means of fungus filaments, which grow out for this very purpose just before death occurs, adhering firmly to adjacent surfaces. A further development then takes place by which the fungus which fills the body of its victim, grows out into the air, forming often greatly elongated stalks, several inches long, but varying with the size of the insects and the special form of the fungus. On these stalks, and usually in connection with a club-like enlargement at the end, myriads of minute spores are formed and scattered in the air or washed on the ground by rains, and each of these excessively minute spores, many millions of which may be discharged from a single club, is capable of reproducing the disease in a new insect. Ants, flies, moths, spiders, beetles, caterpillars, scale insects, cicadas—in fact insects of almost any group are liable to diseases of this nature.

Although little has been done with these types of insect diseases from an economic point of view, there can be no doubt that they are an important factor in destroying many noxious forms, the so-called imperfect forms of certain species, which can be readily handled by means of artificial cultures, having been employed in this way with success; the most recent attempt in this direction being that of the Mycologist of the Board

of Agriculture in Trinidad, who is now testing the use of the so-called Green Muscardine fungus on certain insects destructive to sugar cane. Many similar forms are destructive to scale insects and some of these have also been used in the Southern United States. Though comparatively little attention has been given to this subject by economic entomologists and others, the artificial culture and propagation of these diseases is a matter that deserves far more attention than has yet been given to it.

Australia and New Zealand appear to produce the largest known species, and "vegetable worms" are well known in these countries. A considerable number of interesting forms have also been found in Java. Almost nothing, however, is known about them in Borneo, and in the other East Indian Islands, so that anyone finding such productions who will take the trouble to dry them and send them to the Museum packed in cotton or soft paper in a stout box, will be almost certain to have contributed a specimen of unusual scientific interest.

In addition to diseases such as those above described, which are necessarily fatal to the insects which they attack, there are certain other types of fungus parasites which, although they grow on living insects, and occur nowhere else in nature, are quite harmless to their hosts; the latter thus become the unwilling bearers of a flora which may grow in little forests on their integuments, which they seldom penetrate to any extent. The insect is thus able to live for both without great inconvenience and these singular plants, the forms of which in some cases are bizarre to a degree, have reached an extraordinary development in modern times, not only as to numbers but in respect to the multifarious modifications which have been brought about by their varying conditions of existence on different hosts. They are propagated by direct contact from one insect to another and although the largest species are visible to the naked eye, many are so small that they can hardly be detected with a powerful hand lens; and even then only by one who is expert in these matters. Small beetles, flies, earwigs, roaches and various other insects with overlapping generations of adults, are bearers of these extraordinary plants, which reach